



The Maps of the People: Perceived Environmental Vulnerabilities of Cimarron County, Oklahoma

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Background and Significance

Cimarron County, Oklahoma was the heart of the infamous 1930s Dust Bowl (Vadjunec and Sheehan 2010). Recently, the region faced a 15-year long drought beginning in 2000, a drought designated by the US National Drought Mitigation Center as extreme to severe (Fagin et al. 2016). As the heart of the Dust Bowl's drought, locals of Cimarron County and surrounding areas (Fig. 1) have witnessed or have passed down ancestral tales of the intense transformation of the land from huge dust storms of the 1930s into a land of seasoned farmers and ranchers who must adapt to combat the present environmental hazards (Porter 2013). These hazards include flash flooding in times of sudden precipitation, invasive species (namely plants and herbivorous mammals, e.g. prairie dogs) and, of course, drought. Sparse literature exists examining these woody plants in the area, though Fagin et al. has introduced that salt cedar, cholla, one-seed juniper, and mesquite are encroaching (2016). As a response to these invasive species, residents of Cimarron County have employed various types of technology to adapt, including center pivot irrigation, Internet technology, and precision agriculture. A key factor in the spread of these species is governing policies regarding state trust land in Oklahoma that impact land-use judgments of agriculturalists. Many ranchers perceive the state trust land system as unfair, and have little incentive in practicing sustainable grazing methods because of the uncertainty of renewing the same lease in the next five years (Vadjunec and Sheehan 2010; Fagin et al. 2016). Here, we present the results of a sketch mapping exercise in Cimarron County to assess how local residents perceive their surrounding landscape despite this uncertainty, how they utilize the land, and how they perceive their vulnerabilities. Such understandings will allow the adaptation of current practices to better utilize the land, rather than replacing the practices altogether. Further, the research compounds upon ongoing research funded by a National Science Foundation Award #1266381 (Vadjunec et al. 2013).

Methods

Three major types of data collection were implemented. The first, participant sketch-mapping, allowed us to collaboratively procure maps with locals of perceptions for environmental hazards, focusing specifically on drought, flooding, technology, and invasive species. We sampled residents in local businesses and community functions in Boise City, Keyes, Felt. Participants were given the option to anonymously fill out their own map, or receive assistance from a member of the research team. The 50 collected sketch maps were then digitized into composite maps for each category (drought, invasive species, etc.) by scanning them into ArcMap software and georeferencing to determine perceived hotspots of vulnerability by Cimarron County locals (Scott and Janikas 2010). From these composite maps, we generated standard deviation ellipses for each category for a "general consensus" of locals' perceptions using the Directional Distribution tool in ArcMap. Finally, we accessed secondary sources to compare these ellipses to hotspots designated by remotely sensed data from the USGS National Elevation Dataset for flood vulnerability, WorldClim Global Climate Database for precipitation and drought data, and Fagin et al.'s land cover change maps for land cover change and invasive species (2016).

Scope and Limitations

While a ranching and farming way of life is common throughout the southern semiarid Great Plains, the scope of our research focused primarily on Cimarron County, Oklahoma, and Union County, New Mexico. This was a limitation in itself, as many respondents lived in or near Boise City, Oklahoma, and were chiefly familiar with their immediate surroundings. During our time in the field, we encountered a few other limitations in the process. In some instances, timing and placement may have caused the respondents to be more hurried than others, resulting in potentially less detailed results. Some respondents preferred that we would draw their map for them, which potentially removed their personal details in mapping. Another limitation was a possible location bias, a result of the majority of maps being collected from the Boise City area. Despite this, results indicate a diverse area of perceptions throughout the county.

Figure 1: Study Area

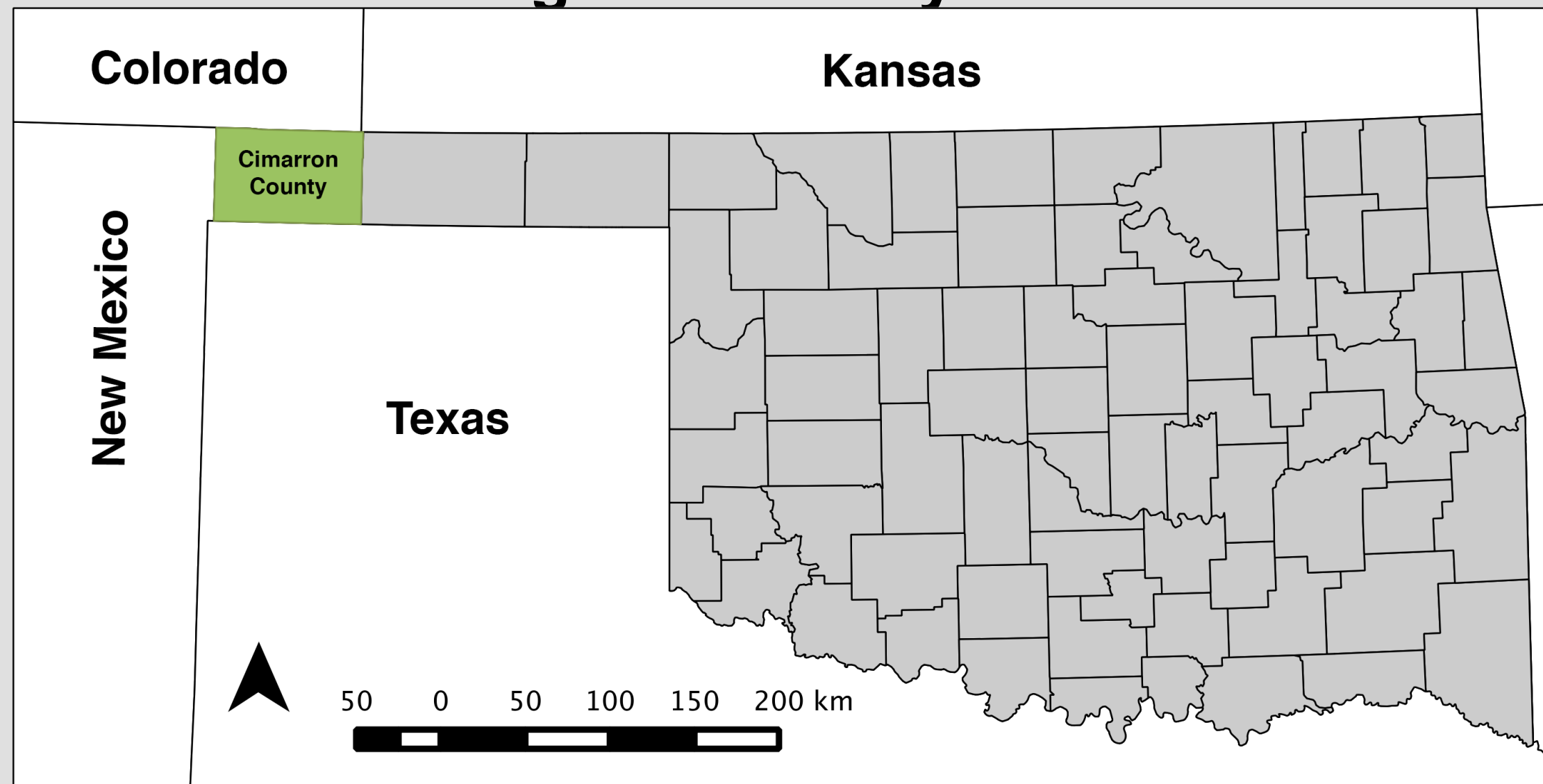
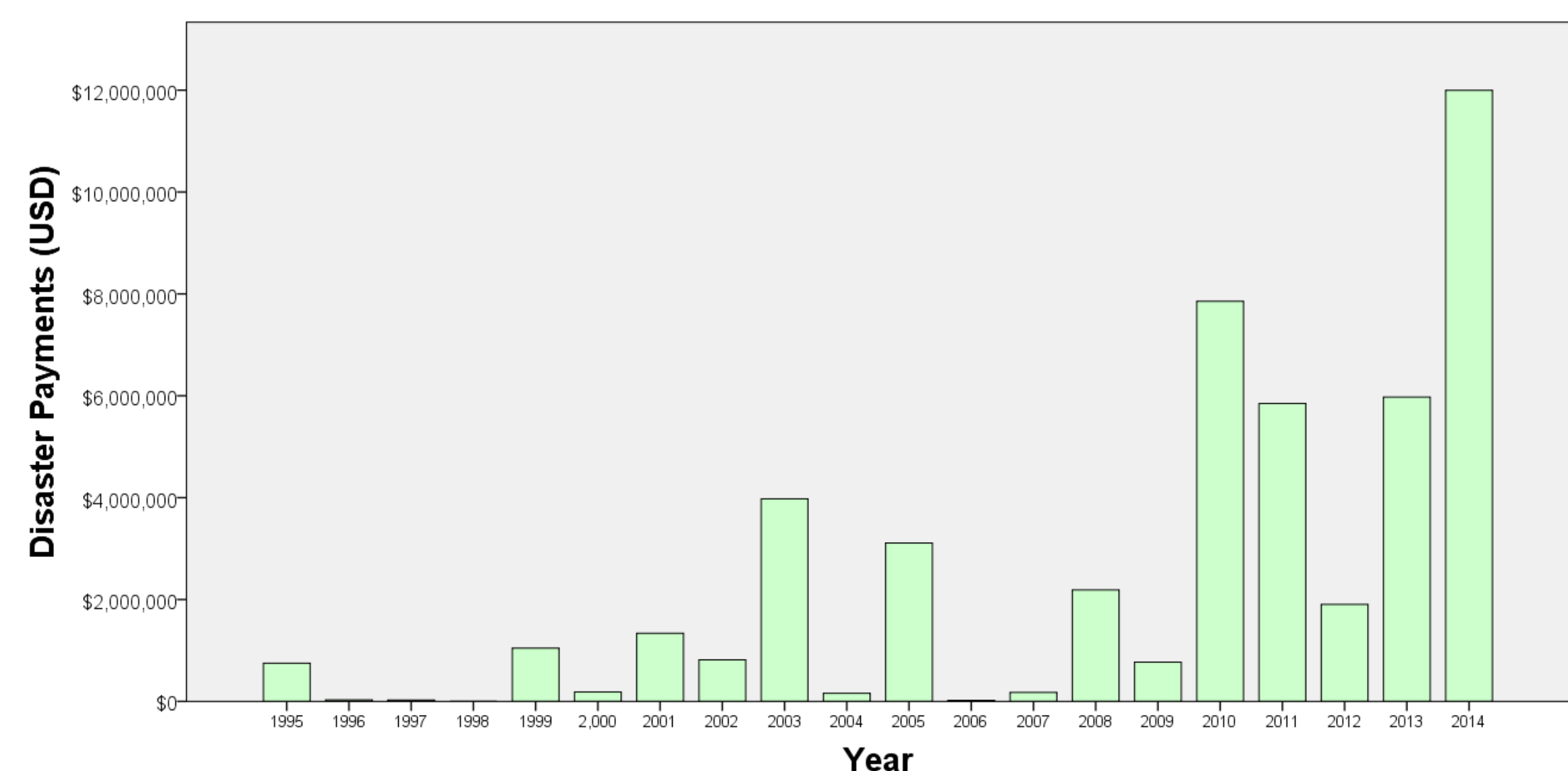
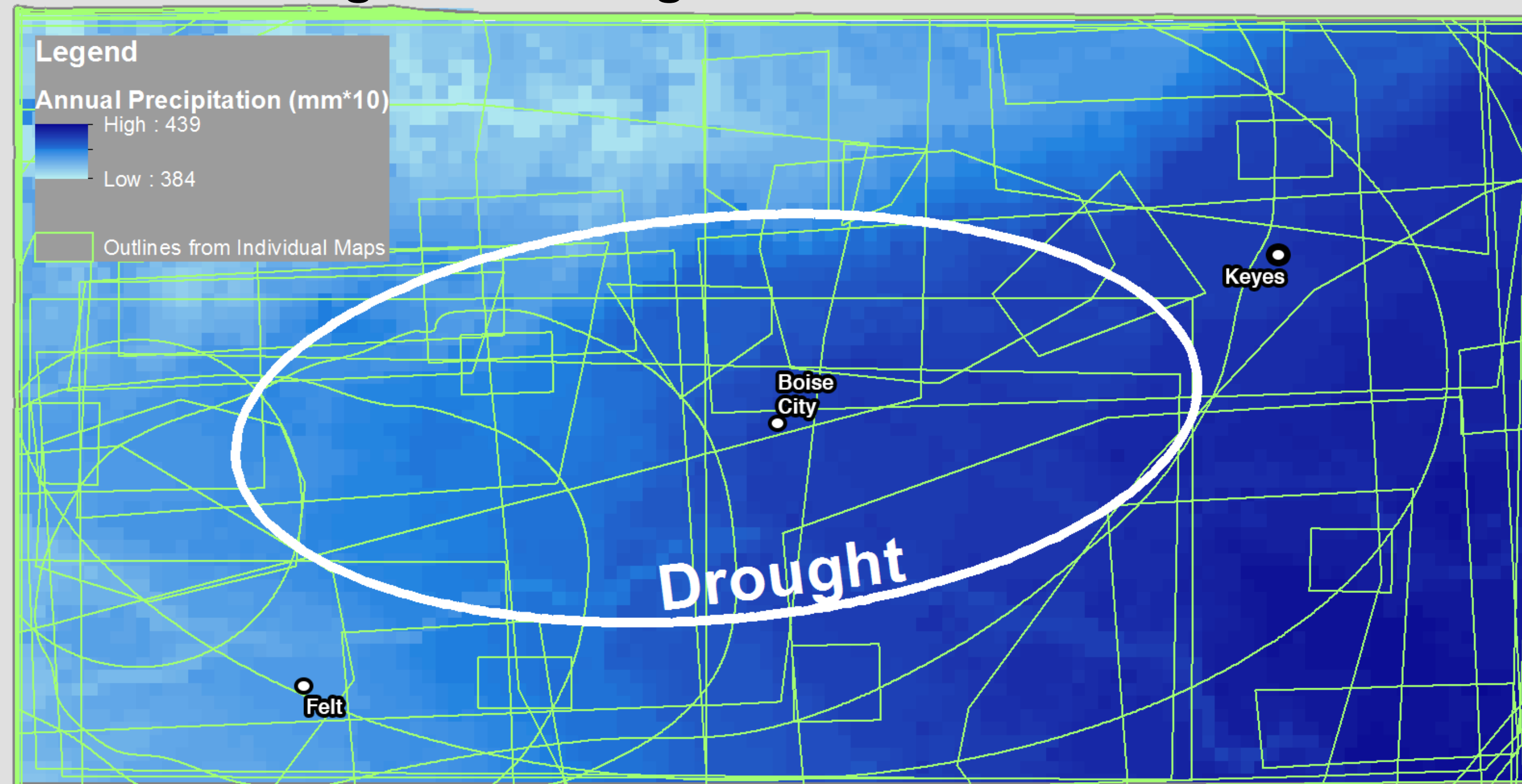


Figure 2: Disaster Relief Payment Chart



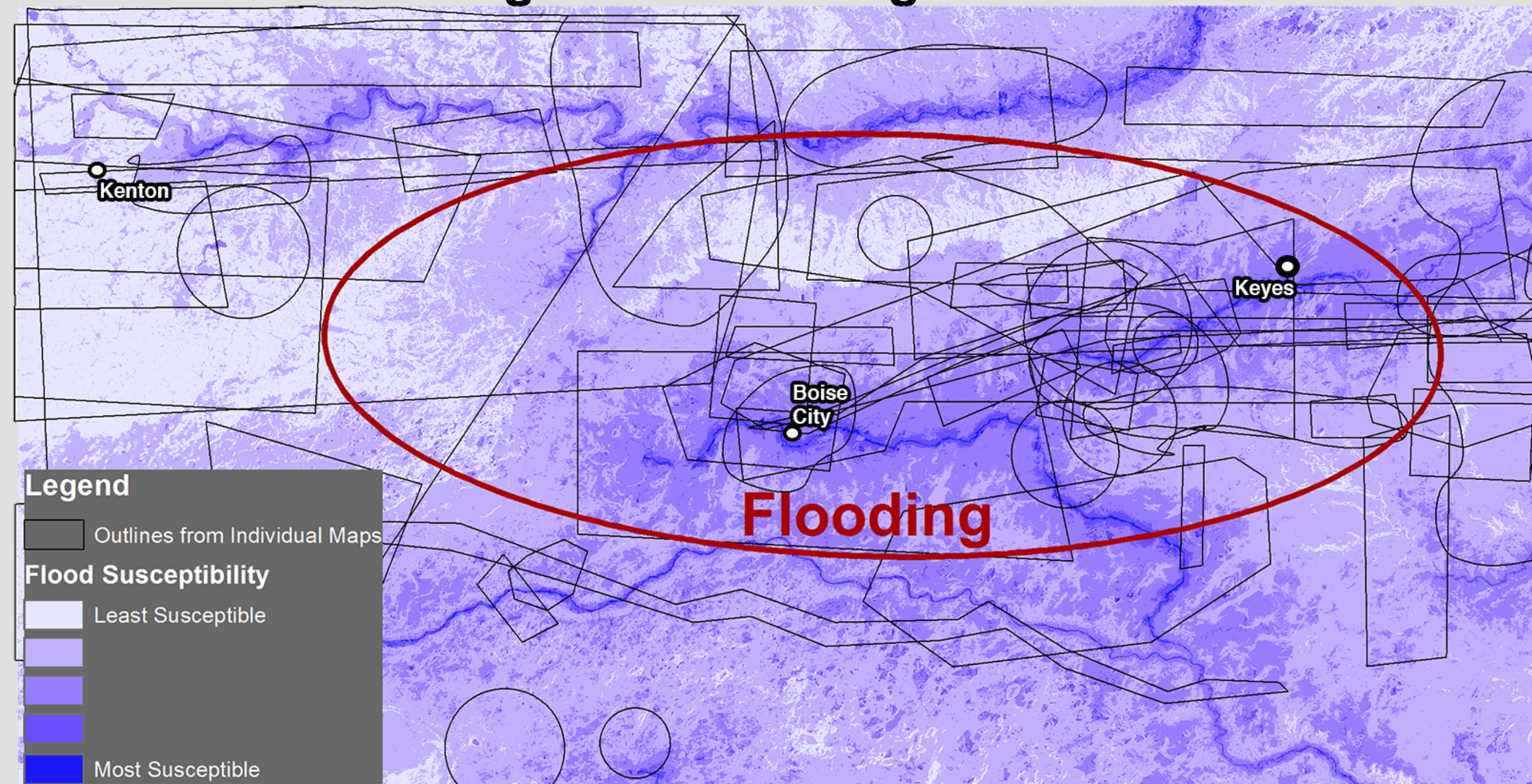
Disaster relief payments for Cimarron County have risen consistently since the onset of the drought that has persisted since 2000. (Adapted from EWG Farm Subsidy Database, 2016).

Figure 3: Drought and Rainfall Results



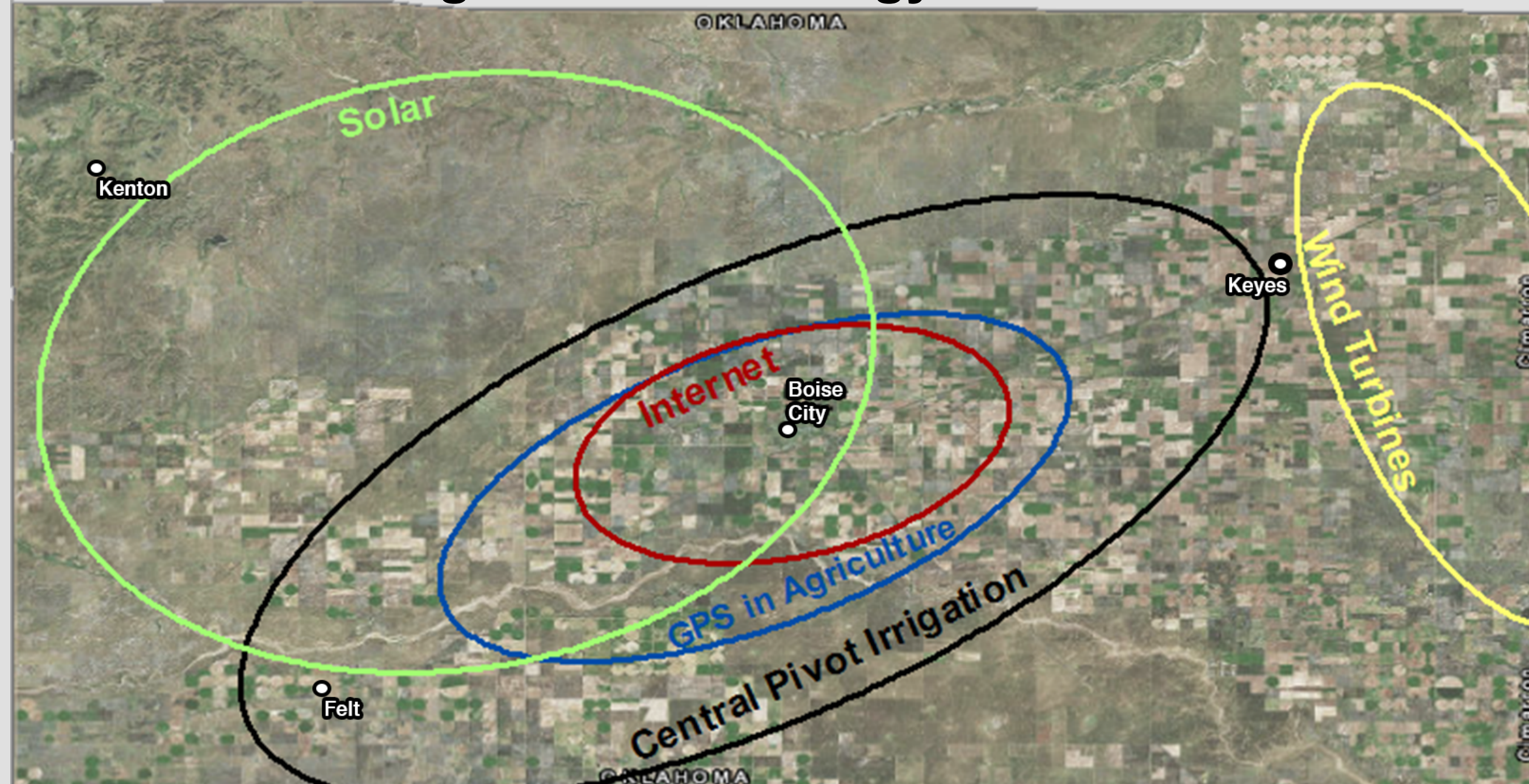
This white oval traces a composite standard deviational ellipse representing the location of the majority of responses from all sketch maps for drought. The ellipse encompasses a large portion of the county, which is consistent with many informants' perceptions that the all portions of the county are equally afflicted by drought. Many informants also circled parcels of land that correlated with property they owned. Although remotely sensed data indicated greater precipitation to the east, sketch maps did not reflect that gradient. (Precipitation data adapted from WorldClim Global Climate Database, Hijmans et al., 2005).

Figure 4: Flooding Results



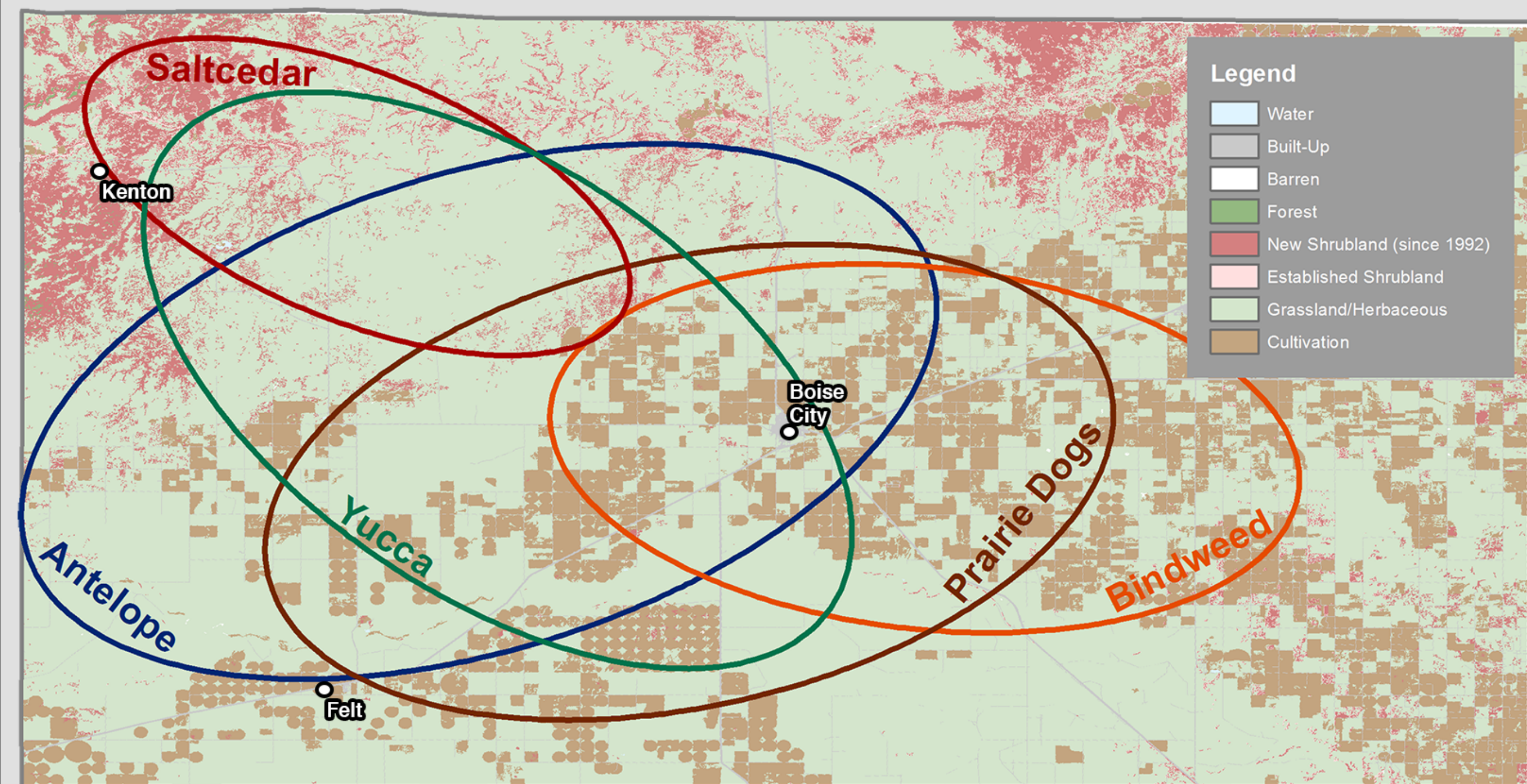
Informants consistently identified low-lying flood-prone areas throughout the east-central portion of Cimarron County, as shown in the red standard deviational ellipse. This is consistent with our flood susceptibility data, and suggests that residents of Cimarron County are acutely aware of flooding hazards in the region. Sketch map responses tended to cover small areas, particularly near major rivers. (Flood susceptibility data were generated from slope and distance from streams maps derived from the USGS NED, 2015).

Figure 5: Technology Results



A composite ellipse derived from all sketch maps accurately showed where wind turbine development is currently ongoing. The standard deviational ellipse for solar energy was also consistent with known adoption of the technology by ranchers in northwestern Cimarron County. Informants said center pivot irrigation was broadly distributed throughout agricultural land. Responses for GPS-enabled agriculture (also known as precision agriculture, where GPS can guide tractors or inform crop placement decisions) covered a similar but smaller area in south-central Cimarron County. Although the entire county has access to the internet, many informants cited Boise City as having the most prominent usage. (Imagery from ESRI).

Figure 6: Invasive Species Results



As shown in the land cover change base map, woody plants have encroached on grasslands across northern Cimarron County since 1992. Many residents accurately sketched salt cedar in the northwestern portion of the county, as outlined by the red standard deviational ellipse. Responses for yucca followed a similar trend, but appeared to extend further south and east. Informants said antelope and prairie dogs are widely distributed across agricultural lands, particularly in areas surrounding Boise city. The standard deviational ellipse for bindweed, a common nuisance cited by farmers, encompassed mostly cultivated land. (Land cover change data adapted from Fagin et al. 2016).

Conclusions

The emergence of Cimarron County's drought and invasive severity correlates with the EWG's Disaster Relief Payment data (Fig. 2). Since the drought's beginnings in 2000, annual disaster payments to Cimarron County agriculturalists have consistently increased. The consensus of perceptions to natural hazards represented by the standard deviational ellipse reveal mixed results in comparison to the associated remotely sensed data.

- In terms of drought, most respondents felt that the entire region was equally susceptible, and thus the standard deviational ellipse covered much of the county, as seen in Fig. 3. However, precipitation data from the WorldClim database indicates that a gradient exists from less precipitation in the western part of the county to more precipitation in the eastern part. The ellipse extends from the mid-western to mid-eastern section of the county, revealing no relationship between actual precipitation data and informants' perception. The large area of mapped perceptions, however, indicates that Cimarron County residents are cognizant of the extent of the current drought.
- Perceptions of flooding align well with USGS data, indicating that residents are quite aware of where flash flooding is likely to occur (Fig. 4). Respondents frequently verbalized their spatial awareness of streams and playa lake zones. This is likely due to the prized nature of water in the region – because it is so rare to find, locals generally know if sources exist, and thus are aware if it will flood.
- The subcategories of technology had ellipses that overlapped with areas of development shown in the satellite imagery, as well as respondents' oral accounts (Fig. 5).
- The small ellipsis for wind turbines overlaps almost directly with where the proposed project for wind farm development is. The farm is centralized in Texas County, but spills over slightly into Cimarron County, almost exactly where respondents indicated.
- Solar panels are more commonly used in the northwestern region as a power supply for water wells.
- Though most respondents noted that everyone in Cimarron County has internet coverage, they narrowed down the concentration to mostly the Boise City area due its high urbanity compared to the rest of the county.

When asked about invasive species, respondents chiefly discussed prairie dogs and antelope, though yucca, bindweed, and salt cedar were also mentioned. The standard deviational ellipse of prairie dogs and bindweed were concentrated on cultivated land in the center of Cimarron County, while salt cedar was perceived as prevalent in the northwest corner of the county (Fig. 6). Yucca was perceived as a threat mostly to grassland/herbaceous terrain type (Fig. 6).

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